ECE 8270 — The Finite Difference Method in Electromagnetics
Fall 2020 Syllabus revision 1

Instructor:	Anthony Q. Martin
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Course Info:	**ECE 8270** — The Finite Difference Method In Electromagnetics
Class Time:	8:00a to 9:15a, MW (Online Synchrouous)
Location:	Zoom Meeting ID: 999 5997 9662 Passcode: 504449
Requried Text:	The Finite-Difference Time-Domain Method for Electromagnetics with MATLAB Simulations, Elsherbeni and Demir, 2nd Edition, SciTech (hard copy) The Finite-Difference Time-Domain Method for Electromagnetics with MATLAB Simulations, Elsherbeni and Demir, 2nd Edition, SciTech (soft copy) The M-files may be found here. Be sure to click on the "Supplementary Materials" tab. **Personal Notes of Instructor, On Canvas.**
Objectives:	The first objective is to provide the student with a working understanding of the finite difference method and the finite–difference time-domain (FDTD) method for the computation of electromagnetic fields and waves. The background obtained is intended to allow the student to conduct research and/or effectively use commercial CEM (FDTD) computer codes for electromagnetic simulation and engineering. The second objective is to enable AEM students to gain important experience with developing scientific codes & programs for solving EM engineering problems.
Topics:	See later in this document.

Course Policies:

- Due to the pandemic, I reserve the right to modify/change/update/revise this syllabus as necessary to finish this semester without anyone getting sick.
- Since this is an entirely online sychronuous course, you are required to have a computer/laptop with a working webcam, microphone, and speaker. These will be used for our streamed lectures.
- My plan is to post a video of the streamed lecture on the day of the lecture. Note that technical difficulties could prevent this, so it is always best to be present at the lectures. I do have some video lectures from spring 2018 that I plan to post that will be used for backup purposes, in the event that something goes wrong (I prefer not to use those as I don't even remember what I did then and I don't want to go back through them all to figure it out). It is a good idea for each student to have a backup method to attend the streamed lectures. Your personal laptop/computer and a second one at your parent's home in your hometown or in a lab on campus (some place safe). Figure this out ahead of time and do not risk infection to attend a lecture!!
- All computer and written assignments must be the result of your own work. You may discuss issues regarding MATLAB itself but you must not, under any circumstances, share code snippets derived from the book or written solutions/formuations. You are expected to do your own work to complete assignments. This policy will be strictly enforced. Note: if your solution is too similar to that of another student in this course, and it is largely bogus, both of you will be accused of cheating. Thus, it is far better for you to submit your own bogus solutions. ☺ A well posed and discussed bogus solution *could* still result in your receiving a good grade in this course (it depends on just how bogus it is). I believe one learns by producing a well posed and discussed solution, so even if it is not correct (entirely), it is of value.
- Students will need access to MATLAB and MS Office for assignments to be turned in. Please make sure you have these on your personal laptop/computer at the beginning of the term.

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- My personal notes & assignments will be posted on your Canvas. Book notes will not be posted on Canvas. You are required to purchase the book to get the assignments that are from the book. Note: I will be using the book, so you will need it. I will use my own notes in cases where I feel they are better, but the book's coverage will still be useful, as an additional viewpoint is always beneficial. I plan to cover at least the first 7 chapters of the book, even if I use my own notes for part of that. My goal is to get your far enough along with FDTD that you can readily read and understand the rest of the topcis in the book, should you need that material for your research.
- Please check Canvas before "class" for any newly posted material.
- Good grammar is a requirement on all project assignments.
- A report format is required on all submitted assignments. Reasonable neatness is required on work submitted. More will be said on this later, but if you give me stuff that I struggle with reading, I will not reward you for it.
- Your grade will be determined from assignments/projects and a possible final exam. All work is outside of class, however.
- At minimum, a 10-point scale will be used (A=90+, B=80+, C=70+, etc.) to determine your letter grade.
- Students will not work together on assignments. However, some amount of discussion amoug students can enhance learning, but sharing code and turning it the bogus ideas that you get from others is not a good thing. If I detect such, that will impact your grade.
- The final assignment is due via email on Friday, May 11, 2020, by 8 am.

Grade Determination: The grade weighting will be:

Assignments (at least 4, and maybe more)	100 %
Total	100 %

Attendance: Class attendance is optional except during a scheduled in-class exam when attendance is mandatory. However, if you miss a class, see a **classmate** about any assignments that may have been given. If the instructor is late to class by more than 15 minutes, then students may leave without penalty. Note that there will be no in-class assignments. Also, I will not be delivering Zoom lectures if no one is present. So, if for whatever reason there are more than two-contiguous streamed lectures will no student attendance, then I will skip the third lecture though students will still be responsible for the material. If you need to miss as a one-time situation, use the Absence notication feature of Canvas to let me know. But if your plan is simply to not come and wait for me to post a video, and I ended up talking to a computer with no one on the other end, nope! If things go that way, we'll just upload the 2018 videos and call it a day (or a semester). I don't see this happening really, but if it does, we now know what will happen.

Assignments: For this course, each student will be required to turn in, by email or file share, one electronic file for each assignment in a report format (introduction, body discussion, conclusions, labeled figures and tables, attribution, cover page, appendices when needed). These should either in MS Word, Powerpoint, or PDF file. These should contain mathematical derviations, computer programs, computer generated results (i.e., plots and graphs), discussions/commentary, and organized in a logical fashion. All problem statements should be included in the report to make it self-contained. Students are **not** required to

type lots of equations. Writing them by hand, scanning, and cut&paste are sufficient to save time. Your grade will be determined mostly (60%) by the percentage of correctly completed assignment with commentary, with the remaining (30%) being split between technical merit (30%) and form (format, labeling, figures & tlabes, neatness, grammar, 10%). Each assignment will be worth a certain number of points and your grade for assignments will be determined based on a ratio of points earned to total points available. This will be weighted and factor into your final grade as listed above. The due date for each assignment will be announced during lecture, e-mail, or on Canvas (or in the assignment PDF). Any assignment that is more than one (1) week late assignments will be given zero credit.

Filenames: Please name your submitted electronic file according to the following scheme:

lastname_ECE8270_assignment_X.pdf

Here, lastname = your surname and X = the number of the assignment.

Example: Martin_ECE8270_assignment_1.pdf

Zoom Meeting details:

Topic: ECE 8270 Finite Difference Methods (FDTD)
Time: Aug 19, 2020 08:00 AM Eastern Time (US and Canada)
Every week on Mon, Wed, until Dec 2, 2020, 31 occurrence(s)

Please download and import the following iCalendar (.ics) files to your calendar system.
Weekly:https://clemson.zoom.us/meeting/tJ0kcuChqTIsHNZj9N7CuFW-IK7toahDN4mn/ics?icsToken=98tyKuChpz4jE9Octh-FRox5HY_4XfPwtlhdgo1nlkbLVANGRDS7H8kVJr1-GPz-

Join Zoom Meeting
https://clemson.zoom.us/j/99959979662?pwd=OUFOMGtyR201SlZwdHNEamFUdlkwQT09

Meeting ID: 999 5997 9662
Passcode: 504449

TITLE IX STATEMENT: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972.

ACCESSIBILITY STATEMENT: Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to a class should let the instructor know and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848 or by emailing studentaccess@lists.clemson.edu. Students who receive Academic Access Letters are strongly encouraged to request, obtain, and present these to their instructors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to follow this process each semester. You can access further information here: http://www.clemson.edu/campus-life/campus-services/sds/.

Academic Integrity: "As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of

a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately and expeditiously to charges of violations of academic integrity."

http://gradspace.editme.com/AcademicGrievancePolicyandProcedures#integritypolicy

SAFE CAMPUS: Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

a. Ensure you are signed up for emergency alerts (https://www.getrave.com/login/clemson)
b. Download the Rave Guardian app to your phone (https://www.clemson.edu/cusafety/cupd/rave-guardian/)

Learn what you can do to prepare yourself in the event of an active threat (http://www.clemson.edu/cusafety/EmergencyManagement/)

ECE 8270
The Finite Difference Method for Electromagnetics

Topical Outline (subject to change)

1. **Review (from AQM Notes)**
    a. Electrodynamics (fields, potentials, boundary conditions, wave equations, and time-harmonic fields)
2. **Classifications (from AQM Notes)**
    a. Common partial differential equations (PDFs)
    b. Dirichlet and Neumann boundary conditions
    c. Initial conditions
    d. Linear, isotropic, and homogeneous, or not
    e. Open- and closed-region problems
3. **Finite Differences (from AQM Notes)**
    a. Types of difference schemes and meshes (frequency and time domain)
    b. The Yee lattice and the leap-frog algorithm
    c. Accuracy (1^{st} and 2^{nd} order) and stability (The Courant condition)
    d. Numerical dispersion
    e. Scalar and vector fields
    f. Media inhomogeneties
4. **Numerical Solution by Finite Differences (from AQM Notes)**
    a. Solutions of 1D PDEs
    b. Solutions of 2D PDEs
    c. Banded matrix solutions
    d. Iterative solutions
    e. Numerical quadrature
5. **The Finite-Difference Time-Domain (FDTD) Method (Book and/or Notes)**
    a. 1D formulation
    b. 2D formulation
    c. 3D formulation
    d. numerical stability
    e. numerical dispersion
    f. materials
    g. subcell averaging
    h. Lumped elements
        i. voltage courses
        ii. current sources
        iii. resistors
        iv. capacitors
        v. inductors
        vi. distributed
        vii. diodes
    i. program building, simulation, and examples
6. **Source Waveforms and Time to Frequency Transformation (Book)**
    a. common waveforms
    b. Time to frequency
    c. Examples
7. **S-Parameters**
    a. Calculations
    b. Simulations
    c. Examples

8. **Convolutional PML Absorbing Boundary (Book and/or Notes)**
    a. Theory of PML
    b. Theory of CPML
    c. ~~Implementation in code~~
    d. Examples
9. **Near-Field to Far Field Transformation (Book and/or Notes)**
    a. Theory
    b. Implementation in code
    c. Examples
10. **Thin-wire Modeling (Book and/or Notes)**
    a. Theory
    b. Implementation in code
    c. Examples
11. **Scattered Field Formulation (Book and/or Notes)**
    a. Theory
    b. Implementation in code
    c. Examples